Influence of Dietary Irradiated *Curcuma ionga* (Turmeric) on Physiological and Biochemical Parameters of Growing Rats

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**ABSTRACT**

Turmeric, (*Curcuma ionga*), is a dietary antioxidant and has been known since ancient times to possess therapeutic properties. The present investigation examined the correlation between raw and irradiated turmeric powder (at dose levels of 10, 15 and 20 kGy) intake and the physiological effects on organs weight, hematological parameters, indices of liver function and lipid profile in growing Albino male rats. Also, this study was performed to examine the efficacy of radiation processed turmeric powder to modulate the induced hyperlipidemia in growing Albino male rats. Thirty six male rats were equally and randomly categorized into six groups. Control group fed a reference diet (casein diet), high fat diet was daily received to rats for 6 weeks. Other animals fed daily on high fat diets containing either raw or irradiated turmeric powder (2 g per100g diet) at doses 10, 15 or 20 kGy for 6 weeks. The results showed that the relative spleen, kidneys, heart, lungs, and testes weight, and the levels of Hb, PCV and MCHC were not changed in animals fed the experimental diets for 6 weeks. Animals kept on HFD suffered from liver enlargement. Dietary interventions through administrating 2% (w/w) raw or irradiated turmeric powder at 20 kGy normalized the liver size as compared with those received reference diet. Meanwhile, the results revealed that rats fed on high fat diet significantly increased plasma AST, ALT, TC and TG and significant decrease was observed in HDL. Meanwhile, feeding rats on diet containing of either raw or irradiated turmeric powder at 10, 15 and 20 kGy induced a significant improvement in the above mentioned parameters. These results imply that irradiated turmeric powder at 20 kGy can offer protection against the biochemical changes as a consequence of hyperlipidimic food and contribute to the regulation of lipid metabolism safely.

**Keywords:** Turmeric (*Curcuma ionga*), Haemoglobin, Liver function, Hyperlipidemia, Lipid profiles, Albino rats, Gamma radiation.
INTRODUCTION

Turmeric (*Curcuma longa* L., Zingiberaceae) is an important tropical spice primarily valued for its color, aroma and antioxidant property. It forms an essential ingredient of curry powder and is extensively used in traditional medicines and foods\(^1\). Turmeric contains bioactive ingredient called curcumin. Several studies have been carried out on curcumin suggest that this natural agent prevents/delays the harmful effect of numerous diseases due to that the curcumin possess high antioxidant and anti-fulminatory properties\(^2\)-\(^4\). Dietary interventions of turmeric/curcumin have been induced various physiological functions such as lowering cholesterol \(^5\), improving liver function \(^6\), suppressing tumor activity \(^7\), and it can be used as an anti-inflammatory\(^8\). Practitioners of traditional Indian medicine believe that curcumin powder is beneficial against many diseases including biliary disorders, diabetes, hepatic disorders, rheumatism, sinusitis, cancer and Alzheimer disease \(^9\)-\(^11\). Recent research has shown curcumin to be a powerful scavenger of the superoxide anion \(^12\), the hydroxyl radical \(^13\) and nitrogen dioxide \(^14\). Also, this agent has been shown to regulate numerous transcription factors, cytokines, protein kinases, adhesion molecules, redox status and enzymes that have been linked to inflammation. The process of inflammation has been shown to play a major role in most chronic illnesses, including neurodegenerative, cardiovascular, pulmonary, metabolic, autoimmune and neoplastic diseases. These features, combined with the pharmacological safety and negligible cost, render curcumin an attractive agent to be explored further \(^15\). Curcumin, also, did not increase lipid peroxidation in adult Wistar rats compared to those not received curcumin (the control group). The dietary curcuminoids have lipid-lowering potency in vivo, probably due to alterations in fatty acid metabolism \(^16\). Diabetic rats fed a curcumin diet also showed lowered lipid peroxidation in plasma and urine when compared to other diabetic groups. Babu and Srinivason \(^17\) reported that the curcumin feeding improves the metabolic status in diabetic conditions, despite that there was no effect on hyperglycemic status or the body weights. The mechanism by which curcumin improves this situation is probably by virtue of its hypocholesterolemic influence, antioxidant nature and free radical scavenging property.

Like other spices, turmeric is prone to microbial contamination and insect infestation during storage and marketing resulting in quality deterioration and economic loss. Exposure to ionizing radiation such as gamma rays is one
of the currently practiced methods of reducing microbial load, disinfesting spices and improvement of safety of spices by activating food borne pathogens. Unlike chemical methods such as ethylene oxide fumigation, which leaves behind toxic residues, gamma irradiation is a safe process. The use of ethylene oxide is banned in several countries including EU and Japan and other countries. Gamma ray irradiation is now internationally recognized as an effective method for maintaining the quality of spices for a long time. Irradiation to an overall average dose of 10 kGy has shown to present no toxicological hazards and to introduce no specific microbial and nutritional problems. The FDA limit for culinary herbs, spices, dried vegetable seasoning and blends of aromatic vegetable substances is up to exceed 30 kGy (Code of Federal Regulation, 2004).

The quantity of irradiated foods in Africa was 90,035 ton and consisted of 17,725 ton of spices and dehydrated vegetables. In Egypt, the quantity of irradiated spices and dry vegetables was 550 ton.

Several studies on spices treated with the doses up to 10-15 kGy have shown that no substantial changes occur in volatile oils, flavor profiles, spicing power and antioxidant properties. However, information on the physiological and biochemical responses of growing rats received in their diets irradiated turmeric has not been investigated. It is, therefore, of interest to study the physiological and biochemical responses of growing male Albino rats received raw or irradiated turmeric at dose levels of 10, 15 and 20 kGy in their diets at levels of 2 g per100g diet for 6 weeks.

MATERIAL AND METHODS

Material

Dry turmeric powder (Curcuma longa L) was procured from the local market and put in glass bottles with screw caps to submit to gamma irradiation from a 60Co source at the National Center for Radiation Research and Technology (NCRRT), Nasr City, Cairo, Egypt. The irradiation facility used was an Egypt’s Mega Gamma-I, of the type J-6500 supplied by the Atomic Energy of Canada Limited. The applied doses were 10, 15, and 20 kGy as monitored by radiocromatic film according to McLaughlin et al. (21). Raw and processed samples were marked for storage at room temperature, until being used.
Animals

Thirty six growing male Albino rats’ weighting 50±5g were procured from the animal housing facility at the NCRRT. The animals were randomly divided into 6 groups, each consisted of 6 rats. The animals were acclimatized under standard conditions of ventilation, temperature, humidity and illumination condition and with 12 light/dark cycle. They were maintained in accordance with the guidelines of the rules of Institute of Laboratory Animal Resources. They were housed to polypropylene cages and were fed the experimental diets and drinking water ad-libitum.

Experimental diets

The experimental diets contained adequate levels of nutrients as recommended by the NRC. The reference diet (casein diet) and HFD (positive control diet) was formulated according to the A.O.A.C. method (Table 1). Quantities of raw or radiation processed turmeric powder (at dose levels of 10, 15 or 20 kGy) were added to pre-weighed experimental diets was 2% (w/w) according to Thapliyed et al. The six experimental diets are as fellow: A reference (casein diet), HFD diet (control diet) (Table 1), HFD diet plus 2% raw turmeric powder 2% irradiated turmeric at dose levels of 10, 15, or 20 kGy. All experimental diets were prepared weekly, and stored at 4°C. Food cups were replenished with fresh diet every day.

Experimental Design

Animals were divided into six groups of six rats each (n=6). Group I: received reference diet (casein diet), Group II: received HFD (positive control diet), Group III: received HFD plus 2% raw turmeric powder, Group IV: received HFD plus 2% turmeric at 10 kGy, Group V: received HFD plus 2% turmeric at 15 kGy, and Group VI: received HFD plus 2% turmeric at 20 kGy. The animals were fed the experimental diets for 6 weeks.

Samples collections

At the end of the experimental duration, animals were fasted over night prior to sacrificing. Final live body weights of animals were recorded. All animals were anaesthetized to collect blood samples and then sacrificed. Whole blood samples were withdrawn by heart puncture technique using heparinized syringes (¼inch needle) and collected in heparinised vials and preserved in ice cold condition, the blood samples were then centrifuged at 5000 rpm for 15 min. Blood plasma was then separated and collected using Pasteur’s pipettes.
and frozen at -20°C until used for biochemical assays. Internal organs (liver, spleen, kidney, heart, lung and testes) from each rat were immediately dissected out and weighted. The relative organs weights were calculated (g of organ per 100g of live body weight). Organs weighted to be used as early toxicological indices for the effects of raw and irradiated turmeric up to 20 kGy.

**Table 1**: Composition of the reference and HFD diets (g kg⁻¹ diet).

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Diet (g kg⁻¹)</th>
<th>Reference (casein diet)</th>
<th>HFD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casein (87 g kg⁻¹, CP)</td>
<td>115.0</td>
<td>115.0</td>
<td></td>
</tr>
<tr>
<td>Corn oil</td>
<td>80.0</td>
<td>80.0</td>
<td></td>
</tr>
<tr>
<td>Palm oil</td>
<td>--</td>
<td>100.0</td>
<td></td>
</tr>
<tr>
<td>Cellulose</td>
<td>10.0</td>
<td>10.0</td>
<td></td>
</tr>
<tr>
<td>Sucrose</td>
<td>125.0</td>
<td>125.0</td>
<td></td>
</tr>
<tr>
<td>Corn starch</td>
<td>560.0</td>
<td>460.0</td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>50.0</td>
<td>50.0</td>
<td></td>
</tr>
<tr>
<td>Vitamin mixture a</td>
<td>10.0</td>
<td>10.0</td>
<td></td>
</tr>
<tr>
<td>Mineral mixture b</td>
<td>50.0</td>
<td>50.0</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1000.0</td>
<td>1000.0</td>
<td></td>
</tr>
<tr>
<td>Crude protein</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

HFD, High fat diet containing 100 g palm oil per kg diet.

*a* The mixture provides the following (mg/100g): Vit. A, 2000 IU; Vit. D, 200 IU; Vit. E, 10 IU; Menadion, 0.5; Choline, 200; mg. Aminobenzoic Acid, 10; Inositol, 10; Niacin, 4; Ca D-Pantothenate, 4; Riboflavin, 0.8; Thiamine. HCl, 0.5; Pyridoxine- HCl, 0.5; Folic acid, 0.2; Biotin, 0.04; Vit. B₁₂, 0.003; Glucose, to make 1000.

*b* The mixture of provides the following: 139.3 g NaCl; 0.79 g KI; 389.0 g KH₂PO₄; 57.3g MgSO₄ anhydride; 381.4 g CaCO₃; 27.0 g FeSO₄.7H₂O; 4.01 g MnSO₄.H₂O;0.548 g ZnSO₄.7H₂O; 0.477 g CuSO₄.5H₂O; and 0.023 g CoCl₂.6H₂O.

**METHODS**

**Heamatological parameters**

Heamatological parameters, heamoglobin (Hb), heamatocreet (PCV) and Mean Corpuscular Haemoglobin Concentration (MCHC), were carried out according to the method reported by Dacie and Lewis (26).

**Biochemical investigations**

Total plasma protein and albumin were assayed according to Henry et al. (27) and Tielz (28), respectively. Plasma AST and ALT activities were determined according to Reitman and Frankel (29). Total cholesterol was
performed according to Allain et al.\textsuperscript{(30)}. High density lipoprotein (HDL) and triglyceride were determined by the method of Demacker et al.\textsuperscript{(31)} and Fossati and Principle\textsuperscript{(32)}, respectively.

**Sample size and Statistical analyses**

For each experiment, three samples were taken. For each sample, three observations were recorded. The mean of these three values was taken as the value for each sample. The data were subjected to statistical analysis of variance (ANOVA) using the general linear model (GLM) according to SAS (SAS Institute)\textsuperscript{(33)}. Linear contrasts and Duncan's multiple-range test were used for comparison of treatments. Data are reported as means with their error. A value of $P<0.05$ was taken as criterion of significant.

**RESULTS AND DISCUSSION**

In groups of control rats fed reference diet (casein diet) as well as those receiving HFD, HFD plus 2% (w/w) raw or irradiated turmeric powder at 10, 15 and 20 kGy for 6 weeks of experimental period, no mortalities were observed.

**Organs weight**

The relative body organs weight of the rats fed the experimental diets for six weeks are summarized in Table (2). The average of the relative spleen, kidneys, heart, lungs and testes weights in animals kept on HFD, HFD plus 2% raw turmeric and HFD plus 2% irradiated turmeric at 10, 15, or 20 kGy during the experimental duration (6 weeks) did not differ when compared with the relative organs weight of these fed reference diet (casein diet). However, animals fed HFD through the experimental duration had significantly suffered from liver hypertrophy at the time of sacrifice when compared with respective weight in group of rats fed reference diet (casein diet) (4.96±0.035 vs 3.426±0.035 g, Table 2).

Turmeric administration before and after irradiation treatment at the applied radiation doses appears to protect animals against the effects of high fat diet-induced enlargement in liver weight. However, the statistical analysis of the data indicated that there are significant differences between group of rats received in their diet raw or irradiated turmeric powder at dose levels of 10 and 15 kGy and those fed reference diet (casein diet). Gradual improvements were observed among group of rats received irradiated turmeric powder in their diets as compared with those received raw turmeric powder. Meanwhile, the data presented in Table 2 indicated that the supplemented high fat diet with 2%
irradiated turmeric at 20 kGy normalized the relative liver weight (3.629±0.132 g) of rats to be close to those fed reference diet (casein diet) (3.46±0.035 g).

The effect of adding raw turmeric powder at level 2% (w/w) to rat diets, on the organ weights, in this study, was in good agreement with Babu and Srinivasan (17), who reported that the rats fed curcumin diet had a lowered relative liver weight and also body weight improved comparing to rats fed high fat diet. However, Jun-ichi and Morio (34) who reported that the excessive curcumin intake did not affect the growth and organs weight of rats. Therefore, it is thought that supplementing turmeric as a component of food is not harmful on rat growth and organs weight in the range of curcumin consumption measured. Subba et al. (35) reported that curcumin maintained body and liver weights, correcting the ill effects in this respect caused by ingested cholesterol. It is believed that curcumin is a potent antioxidant and anti-inflammatory agent (35).

Generally, it could be concluded that the protective effect of adding raw or irradiated turmeric against high fat diet-induced increase in relative liver weight have been seen and increasing radiation dose to 20 kGy ameliorate this protective action.

Table (2): Relative organs weight (g per 100g body weight) of rats fed diets supplemented with raw and irradiated turmeric powder (2%, w/w) up to 20 kGy.

<table>
<thead>
<tr>
<th>Experimental Diets</th>
<th>Liver</th>
<th>Spleen</th>
<th>Kidneys</th>
<th>Heart</th>
<th>Lungs</th>
<th>Testes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference diet</td>
<td>3.426 ±0.035</td>
<td>0.338 ±0.001</td>
<td>0.708 ±0.026</td>
<td>0.283 ±0.006</td>
<td>0.538 ±0.017</td>
<td>1.421 ±0.027</td>
</tr>
<tr>
<td>(casein diet)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HFD (positive control diet)</td>
<td>4.964 ±0.067</td>
<td>0.338 ±0.004</td>
<td>0.729 ±0.030</td>
<td>0.284 ±0.006</td>
<td>0.541 ±0.012</td>
<td>1.425 ±0.052</td>
</tr>
<tr>
<td>HFD plus raw Turmeric</td>
<td>4.143 ±0.140</td>
<td>0.339 ±0.022</td>
<td>0.719 ±0.024</td>
<td>0.286 ±0.011</td>
<td>0.542 ±0.021</td>
<td>1.376 ±0.186</td>
</tr>
<tr>
<td>HFD plus irradiated turmeric (10kGy)</td>
<td>3.947 ±0.206</td>
<td>0.337 ±0.001</td>
<td>0.708 ±0.033</td>
<td>0.286 ±0.004</td>
<td>0.546 ±0.029</td>
<td>1.436 ±0.175</td>
</tr>
<tr>
<td>HFD plus irradiated turmeric (15kGy)</td>
<td>3.754 ±0.199</td>
<td>0.338 ±0.003</td>
<td>0.729 ±0.044</td>
<td>0.283 ±0.004</td>
<td>0.548 ±0.030</td>
<td>1.380 ±0.061</td>
</tr>
<tr>
<td>HFD plus irradiated turmeric (20kGy)</td>
<td>3.629 ±0.132</td>
<td>0.338 ±0.002</td>
<td>0.714 ±0.035</td>
<td>0.285 ±0.007</td>
<td>0.548 ±0.019</td>
<td>1.439 ±0.078</td>
</tr>
<tr>
<td>Probability</td>
<td>0.0001</td>
<td>1.0000</td>
<td>0.9923</td>
<td>0.9982</td>
<td>0.9993</td>
<td>0.9972</td>
</tr>
</tbody>
</table>

HFD, High fat diet.

a-d, Means within a column with no common superscript differ significantly (P< 0.05).
**Heamatological Parameters**

The statistical analysis of the data presented in Table 3 revealed that haemoglobin (Hb), packed cell volume (PCV) and Mean corpuscular haemoglobin concentration (MCHC) were not significantly changed in blood of growing male Albino rats fed high fat diet, high fat diet plus 2 % raw turmeric powder (w/w) or high fat diet plus 2 % irradiated turmeric powder at dose levels of 10, 15 or 20 kGy, compared to those received reference diet (casein diet) for six weeks. Meanwhile, there are no significant differences between groups of rats received irradiated turmeric in their diets, as compared with those received non-irradiated turmeric powder.

The aforementioned results indicated that the dietary interventions for 6 weeks through administrating raw or irradiated turmeric powder, up to 20 kGy, did not induced any harmful effects on the Hb, PCV or MCHC of the experimental animals.

Table (3): Effect of dietary interventions of raw or irradiated turmeric powder at level 2% (w/w) for six weeks on haematological parameters in male Albino rats.

<table>
<thead>
<tr>
<th>Experimental Diets</th>
<th>Hb (g dl⁻¹)</th>
<th>PCV (%)</th>
<th>MCHC (g dl⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference diet (casein diet)</td>
<td>12.963±0.138⁺</td>
<td>35.813±0.724⁺</td>
<td>36.227±0.605⁺</td>
</tr>
<tr>
<td>HFD (positive control diet)</td>
<td>13.013±0.077⁺</td>
<td>36.513±0.904⁺</td>
<td>35.711±0.995⁺</td>
</tr>
<tr>
<td>HFD plus raw Turmeric</td>
<td>13.105±0.081⁺</td>
<td>35.938±1.111⁺</td>
<td>36.563±1.073⁺</td>
</tr>
<tr>
<td>HFD plus irradiated turmeric (10kGy)</td>
<td>13.070±0.171⁺</td>
<td>36.238±0.833⁺</td>
<td>36.144±1.159⁺</td>
</tr>
<tr>
<td>HFD plus irradiated turmeric (15kGy)</td>
<td>13.055±0.197⁺</td>
<td>36.475±0.242⁺</td>
<td>35.791±0.483⁺</td>
</tr>
<tr>
<td>HFD plus irradiated turmeric (20kGy)</td>
<td>12.998±0.108⁺</td>
<td>36.488±0.214⁺</td>
<td>35.626±0.390⁺</td>
</tr>
<tr>
<td>Probability</td>
<td>0.9783</td>
<td>0.9721</td>
<td>0.9643</td>
</tr>
</tbody>
</table>

HFD, High fat diet
Hb, Heamoglobin PCV, Packed cell volume
CHC, Mean corpuscular haemoglobin concentration
⁺Means within a column with no common superscript differ significantly (P< 0.05)

**Biochemical Parameters**

As shown in Table 4 plasma total protein level was found to be not significantly changed (P= 0.3351) in growing rats received in their diet high fat diet 2% (w/w) raw or irradiated turmeric powder up to 20 kGy, when compared with those kept on reference diet (casein diet) or with group of rats fed high fat diet without turmeric powder throughout the experimental duration (6 weeks). However, there are slight differences in the concentrations of plasma albumin and globulin between groups of rats kept on high fat diet supplemented with
raw or irradiated turmeric powder at dose levels of 10, 15 or 20 kGy as compared with those received high fat diet sans turmeric powder or reference diet (Table 4). The differences between animal groups couldn't consider from the biochemical point of view as a real differences that could affect the animals' health. On the other hand, the data presented in Table 4 for total plasma protein, albumin and globulin are within the normal range for adult rats aged 6–12 weeks (36). Moreover, the aforementioned results are in good agreement with Venkatesan and Roa (37), who found that treatment with dietary curcumin significantly protected rats from proteinuria, albuminuria, and hypalbumin-aemia. The authors suggested that animals received dietary curcumin exhibited pronounced reduction in lipid peroxidation in livers and kidneys and inhibition of protein oxidative products in livers justify the antioxidant potential of curcumin when consumed naturally through diet. The safety of the consumption of spices–turmeric/curcumin, and their respective active principles was established in animal studies by observing the influence on growth, organ weights, nitrogen balance and blood constituents upon feeding at levels close to human intake as well as up to 100-times the normal human intake (38). Effect of feeding 0.5% curcumin diet was examined in Albino rats, rats maintained on curcumin diet for 8 weeks excreted comparatively less amounts of albumin, urea and creatinine. Dietary curcumin also partially reversed the abnormalities in plasma albumin, urea and creatine in animals fed on high fat diet (17).

Table (4): Effect of dietary interventions of raw or irradiated turmeric powder at level 2% (w/w) for six weeks on plasma proteins of growing male Albino rats.

<table>
<thead>
<tr>
<th>Experimental Diets</th>
<th>Total Protein (g dl⁻¹)</th>
<th>Albumin (g dl⁻¹)</th>
<th>Globulin (g dl⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference diet (casein diet)</td>
<td>4.449±0.054ᵃ</td>
<td>2.700±0.068ᵇ</td>
<td>1.749±0.088ᵇ</td>
</tr>
<tr>
<td>HFD (positive control diet)</td>
<td>4.473±0.077ᵃ</td>
<td>2.403±0.019ᶜ</td>
<td>2.070±0.083ᵃ</td>
</tr>
<tr>
<td>HFD plus raw Turmeric</td>
<td>4.588±0.032ᵃ</td>
<td>2.602±0.046ᵇ</td>
<td>1.986±0.062ᵇ</td>
</tr>
<tr>
<td>HFD plus irradiated turmeric (10kGy)</td>
<td>4.566±0.015ᵃ</td>
<td>2.500±0.041ᵇᶜ</td>
<td>2.066±0.035ᵃ</td>
</tr>
<tr>
<td>HFD plus irradiated turmeric (15kGy)</td>
<td>4.531±0.042ᵃ</td>
<td>2.688±0.105ᵇᵃ</td>
<td>1.843±0.121ᵇᵃ</td>
</tr>
<tr>
<td>HFD plus irradiated turmeric (20kGy)</td>
<td>4.564±0.059ᵃ</td>
<td>2.710±0.059ᵃ</td>
<td>1.905±0.025ᵇᵃ</td>
</tr>
<tr>
<td>Probability</td>
<td>0.3351</td>
<td>0.0143</td>
<td>0.0588</td>
</tr>
</tbody>
</table>

HFD, High fat diet
ᵃ⁻ᵈ. Means within a column with no common superscript differ significantly (P< 0.05).

Plasma enzyme aspartate transaminase (AST) and alanine transaminase (ALT) were used as the biochemical indicators for hepatic damage. Plasma AST and ALT were found to be elevated (P=0.0001) in growing male albino rats
received high fat diet (HFD) when compared with those received reference diet (25.538 vs 22.163 and 10.733 vs 7.517 UL⁻¹, respectively, Table 3). Adding 2% raw or irradiated turmeric powder at 10, 15 and 20 kGy to HFD decreased the hepatic enzyme activities (AST and ALT) of rats maintained on the aforementioned diets for six weeks to be closed to those received reference diet. On top of that, there are no significant differences between groups of rats received 2% irradiated turmeric powder at 10, 15 or 20 kGy in their diets as compared with those received 2% non-irradiated turmeric powder (Table 5).

In the present research, feeding rats on HFD induced significant hike in the plasma activities of AST and ALT, reported above. The significant increase in activities of the studied plasma enzymes might be indicative to injury of the liver cells (Shyamala et al.⁴⁹ and Gao et al.⁴⁰). The increase in AST and ALT was significantly lowered by adding 2% raw or irradiated turmeric powder at 10, 15 or 20 kGy, this means that radiation processing, at the employed radiation doses, does not impaired the function turmeric powder to correct the bad effect that related to consumption of high fat diet. The same result was observed on the AST: ALT ratio (Table 5). The AST: ALT ratio has been used in some studies with human patients and poultry⁴¹. The AST: ALT ratio appears to be a useful index for distinguishing liver disease and may be helpful diagnostically. The nutrition on raw or irradiated turmeric powder caused significant reduction in the hyperactivities of AST and ALT in rat fed HFD. The attainment of near normalcy in the activities of AST and ALT in turmeric powder fed rats reflected the histoprotective effect of turmeric powder. On the basis that the turmeric powder has the capacity to increase bile production and secretion, its possible therapeutic use in the treatment of certain liver disorders has been indicated. The mechanism of digestive stimulant action of turmeric/curcumin in experimental animals revealed to be mediated through phenomenal stimulation of bile secretion with an enhanced bile acid concentration (ingredients essential for fat digestion and absorption) and an appropriate stimulation of the activities of digestive enzymes of pancreas and small intestine.

Table 5 summarizes the effect of dietary interventions of raw or irradiated turmeric powder (at 2%) on the level of plasma lipid constituents in rats fed HFD. The levels of total cholesterol (TC), and triglycerides (TG), were increased in group of growing rats received HFD diet while plasma high density lipoprotein (HDL) level significantly decreased, as compared with those received reference diet (casein diet). Whereat, growing rats received raw or
irradiated turmeric powder in their diets, the level of their plasma HDL was increased and TC, and TG level significantly decreased than in rats fed HFD. Moreover, It was obvious that the increasing radiation dose up to 20 kGy dose not impaired the function of turmeric powder in lowering plasma TC and TG concentration to approach the level of plasma TC and TG in rats kept on reference diet for 6 weeks (P = 0.0001). Generally, the dietary intervention with raw or irradiated turmeric powder (2% w/w) ameliorates the lipid fractions through significant decreases in TC and TG in addition to marked elevation in HDL.

Dietary fats are known to increase plasma concentration of total cholesterol and triglycerides (42). Hyperlipidemia is the result of an oxidative abuse due to free radicals formed by the interaction of HFD (39). The effect of HFD in this study, on the lipid profile, was in agreement with Shyamala et al. (39) and Srinivasan et al. (43). They reported significant increases of TG, phospholipids and TC in plasma of rats post HFD. However, HDL showed a distinct diminution in plasma of HFD animals, compared with the control group.

The above mentioned results coincide with data previously observed by Ramirez-Tortosa et al (5). They noticed that powdered curcumin administration in hyperlipidemic rats elicits a profound influence on lipid metabolism, where curcumin improves the concentrations of cholesterol, phospholipids and triglycerides in serum of hyperlipidmic rats as a result of lipid peroxidation evoked by HFD.

The hypocholesterolemic effect of curcumin can probably be explained by its effect on the stimulation of bile fluid and biliary cholesterol secretion and enhanced excretion of bile acids and cholesterol in feces (44). The curcumin intake improved the proportion of high density lipoprotein and low density lipoprotein concentrations, even at curcumin concentrations found in turmeric, and excessive curcumin intake reduced the serum TG concentration in healthy rats. These results imply that irradiated turmeric powder at 20 kGy, also, may contribute to the regulation of lipid metabolism safely. Therefore, the present results suggested that radiation processing of turmeric powder at 20 kGy conserved its physiological functions such as lowering cholesterol and triglycerides, improving liver function, therefore turmeric preserved through radiation technology could play an important role in the food industry and pharmaceutical applications.
Table (5): Comparison of plasma biochemical parameters in growing male Albino rats maintained in different diets containing 2% raw or irradiated turmeric powder for six weeks.

<table>
<thead>
<tr>
<th>Experimental Diets</th>
<th>AST (U ml⁻¹)</th>
<th>ALT (U ml⁻¹)</th>
<th>AST/ALT Ratio</th>
<th>TC (mg dl⁻¹)</th>
<th>TG (mg dl⁻¹)</th>
<th>HDL (mg dl⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference diet (casein diet)</td>
<td>22.163±0.189</td>
<td>7.517±0.073</td>
<td>2.961±0.050</td>
<td>135.35±0.807</td>
<td>112.28±1.299</td>
<td>80.34±0.456</td>
</tr>
<tr>
<td>HFD (positive control diet)</td>
<td>25.538±0.317</td>
<td>10.733±0.130</td>
<td>2.382±0.071</td>
<td>206.809±11.424</td>
<td>166.53±0.742</td>
<td>67.87±0.809</td>
</tr>
<tr>
<td>HFD plus raw turmeric</td>
<td>22.275±0.096</td>
<td>7.633±0.088</td>
<td>2.931±0.047</td>
<td>163.38±5.448</td>
<td>115.33±0.500</td>
<td>107.33±1.482</td>
</tr>
<tr>
<td>HFD plus irradiated turmeric (10kGy)</td>
<td>22.523±0.357</td>
<td>7.508±0.069</td>
<td>2.964±0.105</td>
<td>151.168±6.374</td>
<td>115.55±2.716</td>
<td>107.08±0.512</td>
</tr>
<tr>
<td>HFD plus irradiated turmeric (15kGy)</td>
<td>22.383±0.453</td>
<td>7.634±0.064</td>
<td>2.946±0.022</td>
<td>143.47±1.129</td>
<td>118.18±9.820</td>
<td>106.50±0.581</td>
</tr>
<tr>
<td>HFD plus irradiated turmeric (20kGy)</td>
<td>20.500±2.500</td>
<td>7.500±0.058</td>
<td>2.984±0.039</td>
<td>141.164±5.954</td>
<td>113.70±2.492</td>
<td>106.45±1.034</td>
</tr>
</tbody>
</table>

* Means within a column with no common superscript differ significantly (P< 0.05).

**REFERENCES**


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تأثير الكركم الغذائي المعالج إشعاعياً على الوعاوى الفسيولوجية والبيوكيميائية
في الجرذان النامية

هنية فتحي غريب النبيل وحمة محمود الشناوي ورفعت جلال حموت
قسم بحوث تطبيقية، المركز القومي لبحوث وتقنية الإشعاع، ص. 29، مدينة نصر، القاهرة، مصر

الكركم هو أحد مضادات الأكسدة الغذائية والعرف منذ العصور القديمة بخصائصه العلاجية، والدراسة الحالية تهدف إلى توضيح العلاقة بين مسحوق الكركم الخام والمعالج إشعاعياً بالجرعة 10 و15 و20 كيلو جرام وتأثير الكركم الفسيولوجي على أوزان الأعضاء الداخلية وقياسات الدم والدائن ووظائف الكبد ومكونات دهون الدم في ذكور الجرذان البيضاء النامية. كما أظهرت الدراسة أيضاً، بدءاً من فاعلية استخدام مسحوق الكركم المعالج إشعاعياً لتعديل وتقييم زيادة الدهون في دماء ذكور الجرذان البيضاء النامية. استخدم في الدراسة ستة وثلاثون ذكر جرذان بيضاء ثانيات، والتي تم توزيعها عشوائياً على ست مجموعات، المجموعة الضابطة (علبة الكازين)، ومجموعة عينة على علاقة مرتفعة مع-cont.